DER
DISTRIBUTED ENERGY RESOURCES

Tech Brief

Energy Storage

Distributed Energy Resources (DER) are a suite of onsite, grid-connected or stand-alone technology systems that can be integrated into residential, commercial, or institutional buildings and/or industrial facilities. These energy systems include distributed generation, renewable energy, and hybrid generation technologies; energy storage; thermally activated technologies that use recoverable heat for cooling, heating, or power; transmission and delivery mechanisms; control and communication technologies; and demand-side energy management tools. Such decentralized resources offer advantages over conventional grid electricity by offering end users a diversified fuel supply; higher power reliability, quality, and efficiency; lower emissions; and greater flexibility to respond to changing energy needs.

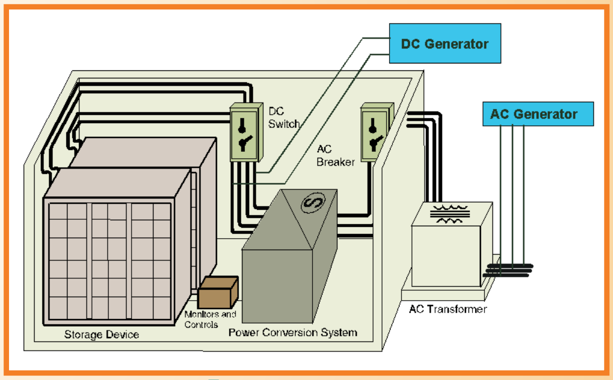
Energy storage allows energy managers to provide energy not only where it is needed but when it is needed—important since both generation and consumption of energy vary by time and season.

Energy storage technologies—including batteries, flywheels, supercapacitors, and superconductors—complement distributed generation and cooling, heating, and power (CHP) systems, which cannot respond to rapid load changes, by providing smooth load-following capabilities. Energy storage also enables greater use of intermittent renewable energy resources.

Energy storage has a number of major application areas, which differ by their power and energy requirements. Short-term, high-power energy storage provides reliability and power quality for the digital economy where outages of a few cycles can lead to costly downtime. Long-term energy storage can mitigate the effects of an overburdened electricity grid by peak shaving and load shifting, while reducing energy costs for consumers.

A wide portfolio of batteries—which store electricity by chemically separating positive and negative charges—is available for electrical energy storage.

- Lead acid (LA) batteries are inexpensive; have well-known operating characteristics; and can provide spinning reserve, voltage, and frequency control for small grids.
- Valve regulated lead acid (VRLA) batteries are sealed and thereby needing less maintenance than regular LA batteries.
- Flow batteries are comprised of a central cell stack that provides power, but total energy is furnished by a reservoir of rechargeable electrolyte, which is scalable and can be located anywhere convenient.
- Zinc-bromine batteries, with integrated power electronics, are entering the marketplace.



Energy storage system

- Vanadium redox batteries feature electrolyte, which can be stored in plastic bags and stuffed into available crawl spaces or other unused areas.
- Lithium Ion, lithium polymer, and nickel metal hydride batteries have been developed mainly for automotive and computer use, but are prohibitively expensive for building applications.
- The sodium sulfur battery is an “advanced battery,” meaning it operates safely at high temperatures and can also supply active and reactive power to mitigate voltage sags and frequency fluctuations.

Market Potential

- Energy storage can avoid billions of dollars of downtime and repair time for high-tech industries, resulting in greater economic productivity.
- Energy storage, coupled with wind farms, would allow the industry to sell blocks of power at premium prices more effectively.
- Energy storage takes advantage of time-of-use rates and high demand charges.

Environmental Benefits

- Energy storage enables use of more renewable energy technologies.
- By increasing productivity, storage allows more effective use of available energy.

Flywheels store kinetic energy within a rapidly spinning rotor or disk, have no hazardous materials, and are well suited for power quality control. They can charge and discharge rapidly, have low maintenance, and a long life span—although power loss is faster than for batteries.

Supercapacitors store electrical energy as charge separation in porous, high-surface-area electrodes. They are capable of very fast charges and discharges and can go through a large number of cycles without degradation.

Superconducting magnetic energy storage (SMES) stores energy in the magnetic field generated by a loop of endless current. Power is available almost instantaneously, with no moving parts and without power loss. However, energy content is small and the system requires cryogenic support.

Applications

Energy storage systems are irreplaceable components of many high-tech operations. Reliability needs, excessive price volatility, and transmission congestion are drivers for extensive deployment of energy storage. Downtime translates to loss of business, costly equipment damage, and equipment and network repair time.

Distributed generation options can be used as backup power, but energy storage systems are needed for "ride-through" power until the backup system can be brought up to capacity. A recent application of six distributed SMES (D-SMES) units in northern Wisconsin enhances stability of an entire transmission loop, whose lines were subject to large and sudden load changes due to the operation of paper mills. Payback times for power quality storage devices ranges from 1 to 2 years in many industries.

200kW/2hr zinc-bromine battery

Longer-term, larger-scale applications of energy storage that allow energy management are still rare, but growing in number. A stationary 20-MW/15-min lead acid system stabilizes Puerto Rico's electric grid. The Tennessee Valley Authority is building a 15-MW/8-hour flow battery system, and a 40-MW NiCd system is being developed in Alaska to support a long power line to Fairbanks. Payback periods may vary from 3 to 10 years.

Program Goals and Activities

The Energy Storage Program seeks to encourage development, testing, and monitoring of a broad portfolio of integrated storage technologies for a wide spectrum of applications, such as:

- Monitoring and economic evaluation of existing storage systems in Alaska and California
- Development and field testing of a Zinc-Bromine system
- Development of a Lithium Ion system for data center applications
- Development of a flywheel with superconducting bearing
- Research on a novel emitter turn-off thyristor for fast, high-power switching
- Development of an intelligent hybrid system controller

For further information:

Office of Power Technologies
www.eren.doe.gov/power/

Distributed Energy Resources
www.eren.doe.gov/der/

Electricity Storage Association
www.electricitystorage.org

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